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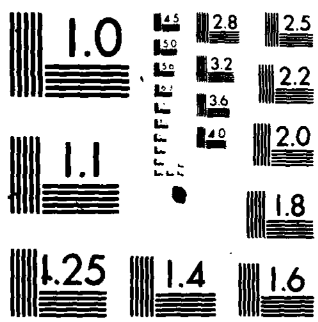

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FABRICATION OF HOLOGRAPHIC OPTICAL ELEMENTS FOR ACHROMATIC MATCHED FILTERING SYSTEM

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Research Directorate
US Army Missile Laboratory

27 January 1982

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Holographic optical elements such as lenses, gratings and holographic matched filters were fabricated for an anchromatic matched filtering system. Diffraction efficiencies of more than 90% were obtained in all these elements. These holographic elements were used in the achromatic matched filtering system and achromatic Fourier transforms were obtained. Experimental details involved in all these methods are briefly described.

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I. INTRODUCTION

In the achromatic matched filtering system, the following holographic optical elements are used (see figure 1): (a) two gratings of 2-inch diameter and spatial frequency of 1000 lines/mm; (b) two lenses of 2-inch diameter, 15-inch focal length and spatial frequency of 500 lines/mm; and (c) a matched filter of some test targets.

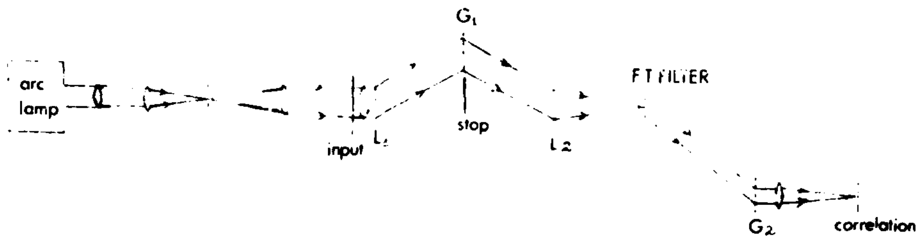

Figure 1

These elements were fabricated on dichromatin gelatin emulsion basically prepared from Kodak 649F standard and microflats of 4- x 5-inch size. Processing of the plates was done as outlined in Reference 4. Diffraction efficiency of more than 90% was obtained. These elements were then cemented together using the procedure mentioned in Reference 4. No degradation in the diffraction efficiency of these elements was found after the cementing. These elements were used in the achromatic matched filtering system (figure 1), and achromatic Fourier transforms were obtained as shown in figure 2. High efficiency matched filters for various test targets were fabricated and used in the system but good correlation was not obtained.

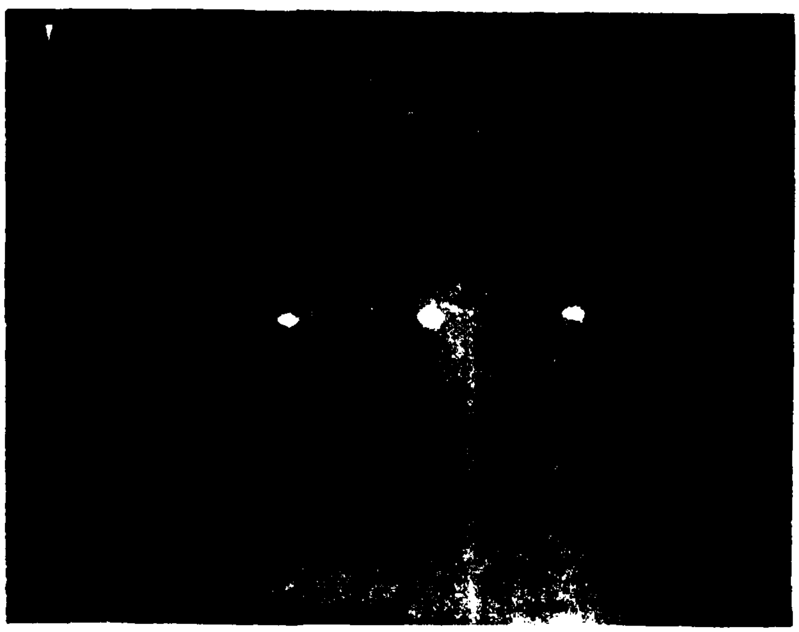

Figure 2

II. GRATING

Phase gratings of very high diffraction efficiency were fabricated by recording the interference pattern between two plane waves from an Argon Ion laser. The angle between the two waves was such that the interference pattern had an average spatial frequency of approximately 1000 lines/mm (including angle of 30°). The arrangement was as shown in figure 3.

The coherent light source was an Argon Ion laser of 4 watts power operating at 514.5 nm. This wavelength was selected to match the prominent line in the mercury arc lamp which was being used in the matched filtering system. The laser had a stable output of 400 mw at 514.5 nm with a coherent stretcher in the cavity. This beam was split into two and focused at the holographic plate at an angle of 30°. The film plane (plate holder) was perpendicular to the bisector of the angle between the two beams. The pathlengths and intensities of these two beams were approximately equal. The patterns were recorded on 4- x 5-inch Kodak 649F standard and microflats sensitized in dichromatin gelatin. The processing of these plates were done as in Reference 4. Room humidity was nearly 40%. The individual beam intensities were approximately 1.5 mw/cm^2 and a total intensity of 3 mw/cm^2 at the plate. An exposure time of 50 sec (150 mj/cm^2) was found to give a diffraction efficiency of more than 90%. A 10% ammonium dichromate solution was used for sensitizing the plates. High diffraction efficiency plates were cemented together following the procedure mentioned in Reference 4.

III. LENS

The optical system is shown in figure 4. The Argon Ion laser was operating at 514.5 nm. In one path the pinhole spatial filter assembly (20X microscope objective and 15μ pinhole) was kept at a distance of 15" from the plate holder which acted as the object beam and the plate holder was kept perpendicular to this beam. The included angle between the two beams is 15°. The pathlengths and the beam ratio of the beams was made approximately equal. A power density of 1.5 mw/cm^2 was obtained for the individual beams giving a total of 3 mw/cm^2 at the plate. An exposure time of 50 sec

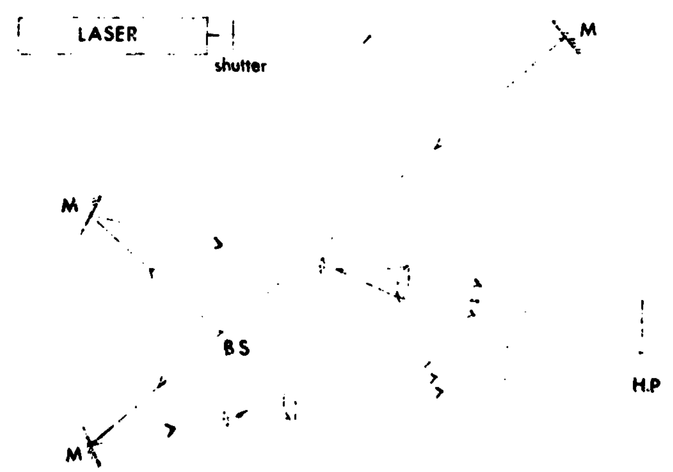

Figure 3

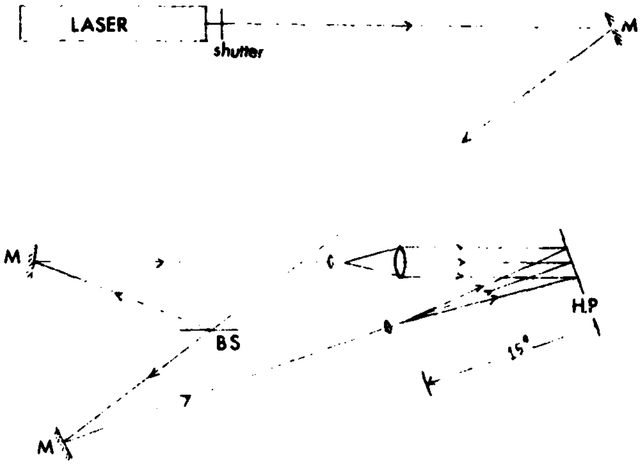

Figure 4

(150 mj/cm^2) was found to give a diffraction efficiency of more than 90%. Holographic lenses of 2" diameter 15" focal length were fabricated using dichromatin gelatin Kodak 649F 4- x 5-inch standard and microflat plates. These plates were demented together using microflats as cover plates following the procedure suggested in Reference 4. The gelatin was removed from used low efficiency microflats by keeping them overnight in a solution of sodiumhydroxide and these microflats were used as cover plates.

IV. HOLOGRAPHIC MATCHED FILTER

Figure 5 is a schematic of the optical system used for making a holographic matched filter. L_1 and L_3 are collimating lenses of 78mm diameter and 381mm focal length. The object is a photographic image (5 x 5mm size) of a tank taken on 649F plate. The lens L_2 is 78mm diameter and 381mm focal length takes the Fourier transform of the coherent image and displays it at the back focal plane of the lens. A holographic matched filter is recorded with this system located at the Fourier transform plane. A dichromatin gelatin plate with 10% concentration is used as the recording medium. The power density of both beams were made approximately equal and a number of exposures with various energy levels from 90 mj/cm^2 to 900 mj/cm^2 were made. A number of high efficiency matched filters were obtained and matched filters of various test targets were fabricated.

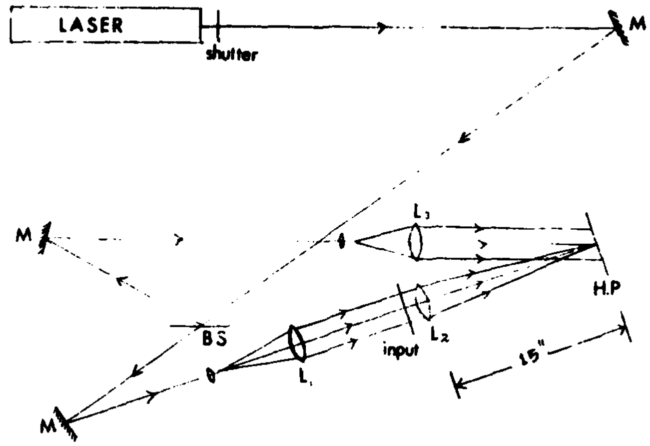

Figure 5

V. ACHROMATIC MATCHED FILTERING SYSTEM

Figure 1 is a schematic of the achromatic matched filtering system used in the laboratory experiments. A Mercury arc lamp is used as the light source and a 25μ pinhole kept at the focusing point acts as a point light source. L_1 and L_2 are the 2" diameter holographic lenses of 15" focal length fabricated on Kodak 649F microflats and G_1 is the diffraction grating. A stop is kept in the path to block the direct beam. All these holographic optical elements were of high diffraction efficiency of more than 90%. The achromatic Fourier transforms obtained without the input is shown in figure 2 whereas figure 6 shows the Fourier transform of the system without using the holographic optical elements.

For the correlation studies, the holographic matched filter was placed exactly at the Fourier plane and precision adjustments were made but it failed to produce good correlation.

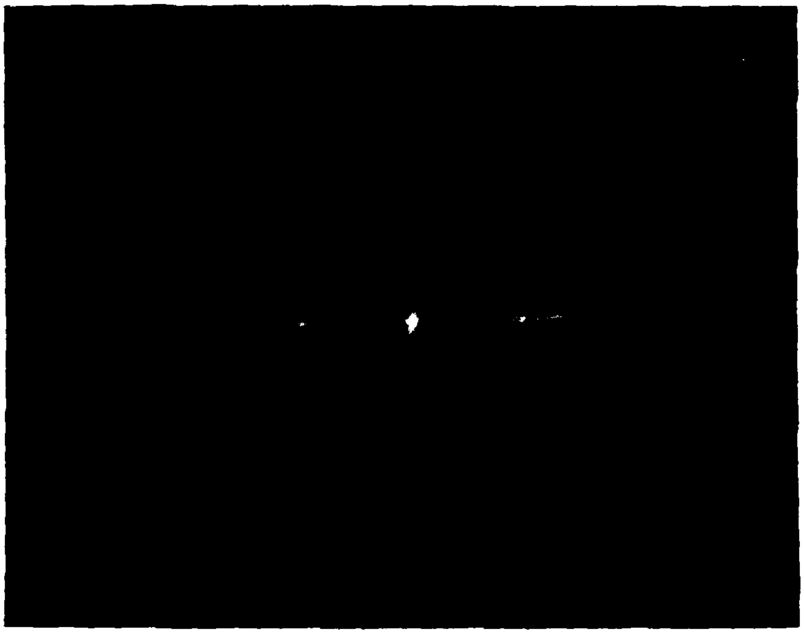

Figure 6

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